

## THE CLAIMS

Having thus described the invention what is CLAIMED is:

5 1. A method for producing hydrogen gas from a hydrocarbonaceous material, using reaction apparatus that includes means for absorbing and releasing thermal energy and having a heat-transfer surface, comprising the following steps, carried out cyclically:

(a) bringing a quantity of a hydrocarbonaceous material into contact with said heat-transfer surface of said means for absorbing and releasing thermal energy, heated to a temperature  $T_{\max}$ , to effect pyrolysis thereof and thereby to produce quantities of solid carbon-rich residue and hydrogen gas;

10 (b) effecting combustion of at least a first portion of said quantity of said carbon-rich residue produced in said pyrolysis step; and

(c) utilizing at least a portion of the thermal energy produced in said combustion step to heat said means for absorbing and releasing thermal energy to said temperature  $T_{\max}$ , for effecting said pyrolysis step in the next succeeding cycle of said method.

15 2. The method of Claim 1 including the additional step of (d) effecting steam gasification of a second portion of said solid carbon-rich residue produced in said pyrolysis step and deposited on said heat transfer surface.

20 3. The method of Claim 2 wherein, subsequent to said pyrolysis step, steam is introduced into the reaction apparatus for reaction with said second portion of said solid carbon to effect said steam gasification step, and wherein the sensible heat of the means for absorbing and releasing thermal energy supplies the heat necessary for said gasification step, said portion of thermal energy produced in said combustion step and used for heating said means for absorbing and releasing thermal energy being sufficient to supply the energy necessary for both said pyrolysis step and also said steam gasification step.



4. The method of Claim 1 wherein a quantity of carbon monoxide is produced, directly or indirectly, from said hydrocarbonaceous material, and wherein said method includes the additional step of (e) effecting a water-gas shift reaction, utilizing at least a portion of said quantity of carbon monoxide produced, so as to produce carbon dioxide and an additional quantity of hydrogen gas.

5. The method of Claim 1 including, in said next succeeding cycle, the additional step of (f) effecting steam reforming of gaseous hydrocarbons produced in said pyrolysis step.

6. The method of Claim 5 wherein thermal energy produced in said combustion step supplies the energy necessary for effecting said steam reforming step.

7. The method of Claim 1 wherein said means for absorbing and releasing thermal energy comprises a bed of a catalyst that is effective for promoting pyrolysis of said hydrocarbonaceous material.

8. A method for producing hydrogen gas from a hydrocarbonaceous material, using reaction apparatus that includes means for absorbing and releasing thermal energy and having a heat-transfer surface, comprising the following steps, carried out cyclically,

(a) bringing a quantity of a hydrocarbonaceous material into contact with said heat-transfer surface of said means for absorbing and releasing thermal energy, heated to a temperature  $T_{\max}$ , to effect pyrolysis thereof and thereby to produce quantities of solid carbon-rich residue and hydrogen gas;

(b) effecting combustion of at least a first portion of said quantity of said carbon-rich residue produced in said pyrolysis step;

(c) utilizing at least a portion of the thermal energy produced in said combustion step to heat said means for absorbing and releasing to said temperature  $T_{\max}$ , for effecting said pyrolysis step in the next succeeding cycle of said method; and

(d) effecting steam gasification of a second portion of said quantity of carbon-rich residue produced in said pyrolysis step.



9. The method of Claim 8 wherein, subsequent to said pyrolysis step, steam is introduced into the reaction apparatus for reaction with said second portion of said solid carbon to effect said steam gasification step, and wherein the sensible heat of the means for absorbing and releasing thermal energy supplies the heat necessary for said gasification step, said portion of thermal energy produced in said combustion step and used for heating said means for absorbing and releasing thermal energy being sufficient to supply the energy necessary for both said pyrolysis step and also said steam gasification step.

10. A power system comprising:

a fuel cell, which utilizes hydrogen for power generation; and

reaction apparatus for producing hydrogen gas, said reaction apparatus being operatively connected for delivering hydrogen gas produced thereby to said fuel cell, and including: means for absorbing and releasing thermal energy and having a heat transfer surface; means for introducing a hydrocarbonaceous material into said apparatus and for depositing the material upon said heat transfer surface for effecting pyrolysis of the material; and means for introducing an oxygen-containing gas into said apparatus for effecting combustion of carbon produced by pyrolysis of the deposited hydrocarbonaceous material, and for thereby delivering thermal energy to said means for absorbing and releasing thermal energy.

11. The system of Claim 10 wherein said system is self-contained.

12. The system of Claim 11 additionally including means for storing a supply of hydrocarbonaceous material operatively connected to said means for introducing thermal energy.

13. The system of Claim 12 comprising a transportation vehicle.